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Stratigraphic studies on the Upper Cretaceous in Central Poland

By

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With 6 text figures

ABSTRACT

Upper Cretaceous rocks are distributed almost throughout the whole Polish Lowlands. They attain maximum thickness, and the sections are most complete in the marginal zone of the East-European Platform. In the Middle Vistula gorge the succession of Cretaceous strata from the Albian to Maastrichtian is excellently exposed. The succession is fairly complete, without any greater stratigraphic gaps. It is rather monotonous, indicating deposition under moderately shallow-water conditions changing to somewhat deeper-water conditions in the Turonian and Middle Maastrichtian. The studies on foraminifera faunas showed marked predominance of calcareous benthos throughout the sequence. The benthic elements are accompanied by pelagic and occasionally arenaceous ones. This allows to establish foraminifera zonation based on benthic and planktonic elements and to correlate them. The foraminifera assemblages recorded in the Upper Cretaceous deposits in the Polish Lowlands are typical of the Boreal Province, with some admixtures of warm-water elements only.

KURZFASSUNG

Oberkreidesedimente sind nahezu im gesamten Tiefland Polens verbreitet. Die vollständigsten Abfolgen und die größten Mächtigkeiten finden sich in der Randzone der Osteuropäischen Plattform. In der mittleren Vistula-Schlucht ist eine Alb- bis Maastricht-Abfolge sehr gut und nahezu komplett ohne größere stratigraphische Lücken aufgeschlossen. Die eintönige Fazies zeigt Ablagerungsbedingungen unter mäßig flachem Wasser an mit Einfluß tieferer Wasser-Bedingungen im Turon und im mittleren Maastricht. Die Foraminiferen-Fauna zeigt eine klare Vormacht des kalkigen Benthos, zusammen mit einigen planktonischen Elementen und gelegentlich Sandschalern. So ist es möglich, eine Zonierung mit benthonischen und planktonischen Formen aufzustellen und beide miteinander zu korrelieren. Die Foraminiferen-Vergesellschaftungen sind charakteristisch für die boreale Faunenprovinz mit nur wenigen Beimengungen von Warmwasser-Elementen.

INTRODUCTION

In the Cretaceous, almost the whole northern and central Europe was flooded by vast epicontinental sea. Laramie movements from the end of the Maastrichtian resulted in regression from previously occupied area, except for some basins. In Poland and adjoining countries, 9 such basins have been recognized. The largest of these basins (I in Fig. 2) was situated in marginal part of the East-European Platform. Upper Cretaceous rocks infilling it were intensively studied by several authors and stratigraphy and foraminifer assemblages of the Upper Cretaceous sequences were the subjects of several our papers. The studies were facilitated by excellent outcrops displaying almost continuous section from the Albian to Paleocene in the Middle Vistula River valley (Fig. 1), as well as almost a hundred drillings, often full-cored, penetrating Upper Cretaceous cover in area eastwards of the Middle Vistula River to the Polish-Soviet boundary. The results of studies on lithology and micro- and macrofauna from these borehole columns appeared to be of great stratigraphic value, making it possible to compile a section through this cover in marginal part of the East-European Platform (Fig. 2). Biozonation of the strata is fairly well established except for the Cenomanian and Campanian-Maastrichtian. In the former case, the diffe-

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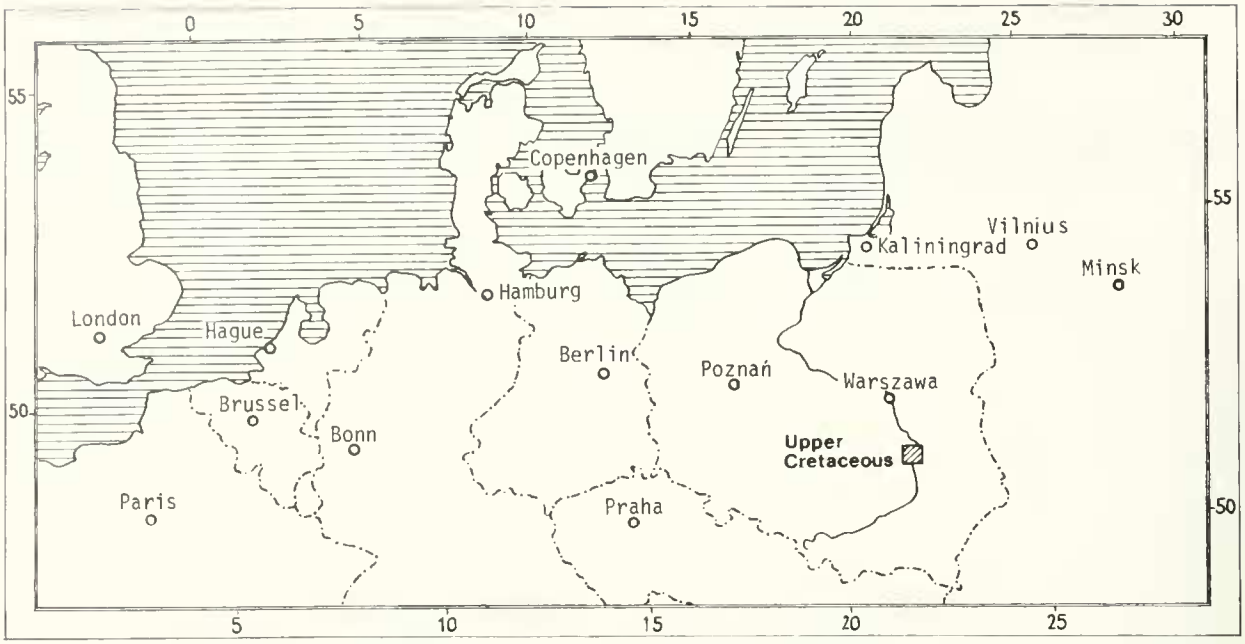

Fig. 1. Location of Upper Cretaceous outcrops in the Middle Vistula River Valley

rences in approach of individual authors may be explained by still unstable sedimentary and environmental regime. Such regime resulted in origin of high variable deposits and often in reduction and condensation phenomena, impeding establishment of biostratigraphic criteria applicable for the whole basin. In the case of the Campanian and Maastrichtian, cephalopod fauna is highly abundant and diversified but biostratigraphic value of individual species is still the subject of discussions and various zonal schemes are proposed (Fig. 4).

LATE CRETACEOUS BASINS IN CENTRAL EUROPE

In central Europe, Late Cretaceous transgression resulted in deposition of sedimentary series varying in thickness and completeness. Sedimentation appears most continuous in basins developed in direct foreland and marginal part of the East-European Platform (Fig. 2). The major depocenters also appear located in the marginal zone and there may be noted a steady trend to decrease in thickenss towards the interior of this platform. The available data clearly suggest the influence of structural differentiation of the basement on development of the basins.

In places where the Platform margin is passing close to its shields, Cretaceous sequence are relatively thin and with significant gaps. For example, the whole lower part of the Upper Cretaceous / Cenomanian-Santonian / is missing in the Karlskrona region in the Baltic Shield. Gaps found in sequences from basin parts most distant from the Platform margin are similar as, e. g., in Lithuania where Maastrichtian rests on various members of lower Upper Cretaceous.

In central Europe, two large basins were active at the Platform margin in the Late Cretaceous. One (marked as I in Fig. 2) was comprising northern and eastern Poland, being delineated by the Ukrainian Shield in the east and the Baltic in the north. It is characterized here in the section shown in Fig. 3. The other (II in Fig. 2) was situated west of the Baltic shield, stretching northwards of Rügen to northern Jyland.

In the foreland of the plarform, characterized by basement of the Paleozoic age and highly complex structure, Late Cretaceous basins appear fairly diversified. The basins are separated from one another by areas in which Cretaceous rocks are partly or completely missing due to erosion related to strong subsiding and uplifting movements. Two regions may be differentiated here. One region displays a series of small basins, generally parallel to the platform margin and characterized by generally continuous sequences in their axial parts and presumably original lack of the uppermost Maastrichtian. Here are recognized the Miechów (III in Fig. 2), Lódź (IV) and Szczecin (V) basins. It should be noted that the two latter basins are displaying very large thickness of the Upper Cretaceous.

The other region comprises basins situated within the area of the Variscan fold belt and characterized by large thickness of lower Upper Cretaceous and complete lack of the higher Cretaceous strata. Here are recognized the Opole (VI) basin, Nysa Klodzka (VII) basin (trough), inner basin of the Bohemian Massif or Praha basin (VIII), and North-Sudetic basin (IX).

The present distribution of Cretaceous rocks fails to give detailed image of original sedimentary basins because of the influence of Cretaceous and post-Cretaceous movements. Therefore, the subdivision presented above should be treated as structural subdivision of basins.

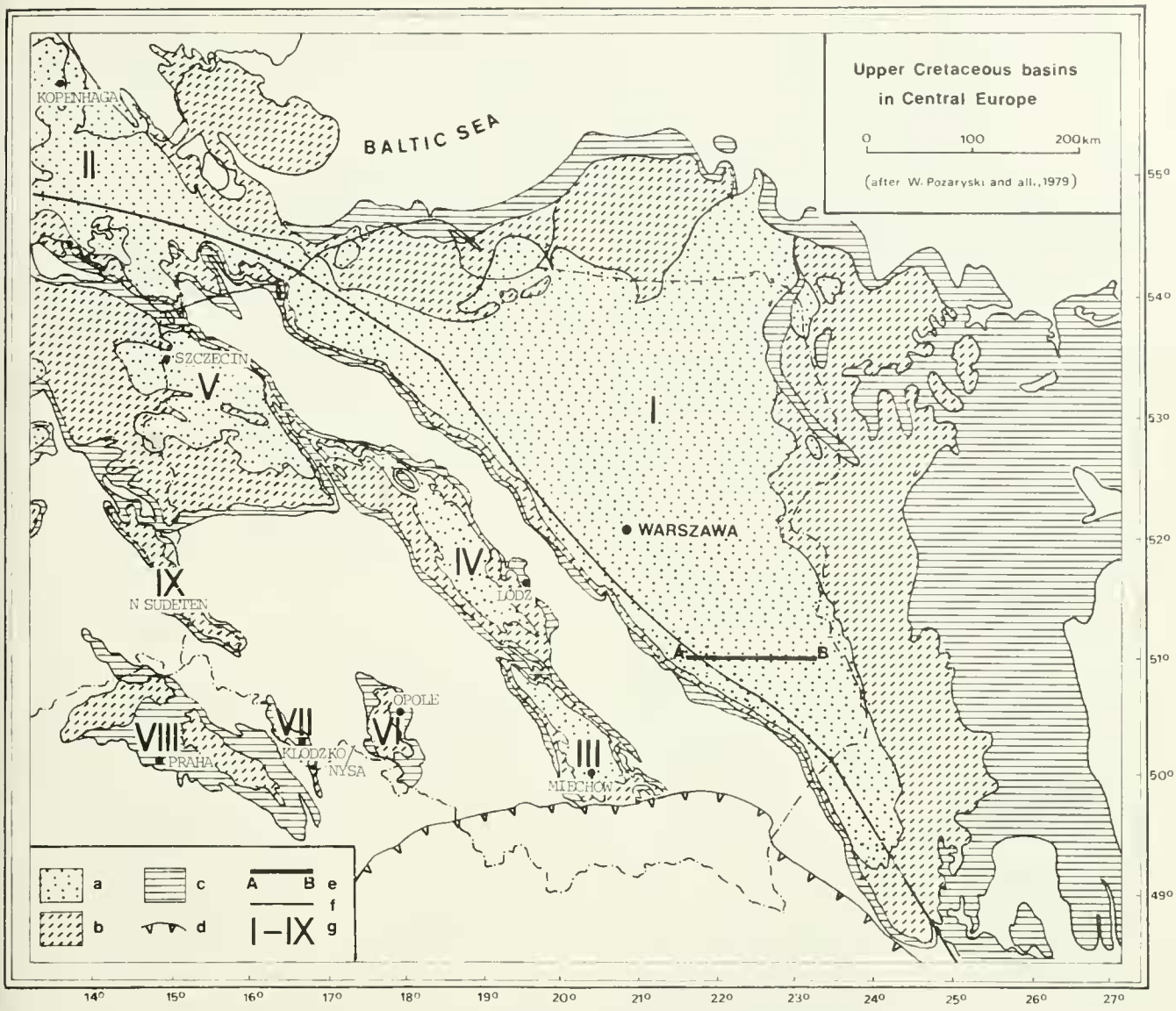

Fig. 2 Late Cretaceous basins in central Europe. White = rocks older than Cretaceous.

a) Maastrichtian
b) Coniacian, Santonian, Campanian
c) Cenomanian, Turonian
d) Carpathians margin
e) Studied section A–B
f) Margin of East European Platform

I – Warszawa Basin
II – Danish Basin
III – Miechów Basin
IV – Łódź Basin
V – Szczecin Basin
VI – Opole Basin
VII – Kłodzko/Nysa Basin
VIII – Praha Basin
IX – North Sudetic Basin

COMMENTS TO THE SECTION A–B THROUGH UPPER CRETACEOUS ROCKS IN CENTRAL POLAND

The section through Upper Cretaceous rocks in central Poland, shown in Figs. 1 and 3, is based on data from 8 boreholes of the Geological Institute and outcrops in the Vistula River valley. The boreholes are located along a line running evenly with 51° parallel of latitude and the section begins in the vicinities of Chełm in inner area of the platform, going westwards through Krasnystaw, Bychawa, Bystrzyca, Niedrzwica and Opole in marginal part of the platform, to Ciepielów and Bakowa, situated in the foreland, in area of so-called Mid-Polish aulacogen.

Upper Cretaceous sequences are fairly thick in borehole columns Bychawa, Bystrzyca and Niedrzwica which are situated within the area of the Mazowsze-Lublin Carboniferous trough, but they attain maximum thickness at the western end of the section. The borehole column Bakowa, situated at the western end, displays Cenomanian-Upper Maa-

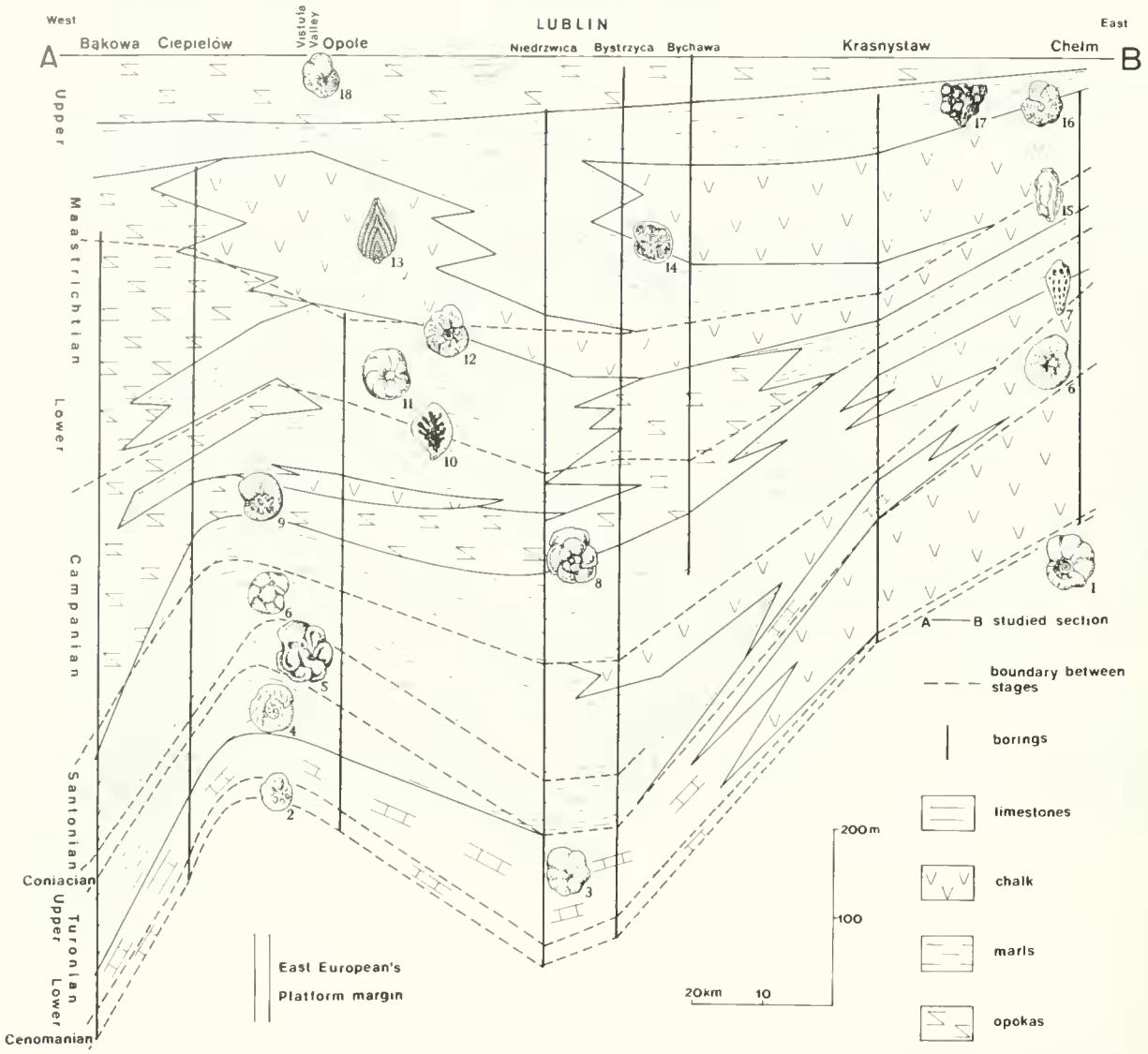

Fig. 3. Section A–B through Upper Cretaceous rocks in central Poland; 1. *Gavelinella cenomanica*, 2. *Lingulogavelinella formosa*, 3. *Gavelinella berthelini*, 4. *Stensioeina granulata interiecta*, 5. *Marginotruncana coronata*, 6. *Stensioeina polonica*, 7. *Bolivinoides strigillata*, 8. *Globotruncana fornicata*, 9. *Anomalina clementiana*, 10. *Bolivinoides draco miliaris*, 11. *Angulogavelinella gracilis*, 12. *Cibicides involuta*, 13. *Neoflabellina reticulata*, 14. *Stensioeina pommerana*, 15. *Pseudouvigerina cristata*, 16. *Anomalinoides pinguis*, 17. *Planoglobulina acervulinoides*, 18. *Anomalina danica*.

strichtian sequence which appears complete except for some erosion of its top part.

In the section, the Upper Cretaceous is developed in 4 lithofacies:

1. opoka lithofacies, especially well developed in western part of the studied area, appeared for the first time in the Campanian and began to predominate throughout the area in the Maastrichtian, especially Late Maastrichtian.

2. marly lithofacies, represented throughout the area, especially in the form of thick lenticular intercalations in its central part; known from the Upper Turonian to Middle Maastrichtian.

3. chalk lithofacies, best developed in borehole column Chełm, where it is displayed by the whole Turonian-Upper Maastrichtian section, except for some Upper Campanian and lowermost Maastrichtian intervals.

4. limestone lithofacies is mainly found in the Cenomanian and, Lower Turonian in the west and Coniacian in the east; limestones are most homogeneous uniform in the Cenomanian, where they form a continuous layer.

Rocks of the above 4 lithofacies do not differ much in macroscopic features. They are white to light-gray in colour and they yield well-developed and preserved foraminifer assemblages (especially in the case of the chalk microfacies). The assemblages appear generally similar to coeval ones from epicontinental Cretaceous rocks in northern Europe, markedly differing from the Tethyan, primarily in smaller share of planktonic forms. This made it possible to assign Cretaceous rocks of the Polish Lowlands to province transitional in character between the Subboreal and Tethyan ones (Pożaryska and Peryt, 1979).

ATTEMPTS TO ESTABLISH ZONATION OF THE UPPER CRETACEOUS IN CENTRAL POLAND ON THE BASIS OF MACRO- AND MICROFAUNA

UPPER CRETACEOUS	MAASTRICHTIAN	Upper	*Belemnella kazimiroviensis* *Sphenodiscus binckhorsti* *Belemnitella junior*
		Lower	*Belemnella occidentalis* *Belemnella lanceolata*
	CAMPANIAN	Upper	*Belemnitella langei* *Bostrychoceras polyplocum*
		Lower	*Neancyloceras phaleratum* *Gonioteuthis quadrata*
	SANTONIAN	Upper	*Inoceramus patootensis*
		Lower	*Inoceramus cardissoides*
	CONIACIAN		*Inoceramus involutus*
	TURONIAN	Upper	*Inoceramus schloenbachi* *Inoceramus costellatus*
		Lower	*Inoceramus lamarcki* *Inoceramus labiatus*
	CENOMANIAN	Upper	*Inoceramus pictus*
		Middle	*Schloenbachia varians*
		Lower	*Mantelliceras mantelli*
	ALBIAN		

Fig. 4. Biozonation of the Upper Cretaceous in central Poland on the basis of macrofauna

The attempts to establish a modern, detailed macrofaunabased biozonation of the Upper Cretaceous in central Poland were initiated in the 30's. The first zonation of monotonous Upper Cretaceous white series in Middle Vistula River drainage basin, based on macrofauna, was proposed by W. Pozaryski (1938, 1948), who also presented correlations with Upper Cretaceous strata in North-Western Europe. Works aimed in these directions were also carried out by R. Kongiel (1935, 1949, 1958), S. Cieśliński (1960), and recently A. Błaszkiewicz (1979, 1980) and R. Marcinowski (1974).

During the world-war II, micropaleontological studies were initiated on the Upper Cretaceous in central Poland (W. Pozaryski, unpublished report). After the war, K. Pozaryska (1954, 1957) decribed 30 guide foraminifer species from these strata, and W. Pozaryski and E. Witwicka (1956) 18 guide globotruncanids species. These works were followed by E. Witwicka (1958), E. Witwicka and S. Cieśliński (1962), E. Gawor-Biedowa (1972), E. Gawor-Biedowa and E. Witwicka (1960), K. Pozaryska and E. Witwicka (1980). Recently D. Peryt (1980) described 91 species of planktonic foraminifers and she proposed 10 biozones. B. Zapalowicz-Bilan (1982) proposed similar subdivision into 10 biozones, based on benthic foraminifers.

The micropaleontological studies resulted in fairly good knowledge of Upper Cretaceous foraminifers and establishment of several micropaleontological-stratigraphic subdivisions. Attempts were made to correlate these subdivisions with detailed subdivisions based on macrofauna (fig. 4). However, that task appeared highly difficult as the stage boundaries delineated with reference to stratigraphic ranges of benthic foraminifers were often found to differ from those delineated on the basis of macrofauna. Generally, the ranges of even most short-living species of benthic foraminifers are several times wider than those of ammonites, belemnites and inoceramids. In attempts to correlate these subdivisions, boundaries of stratigraphic zones are defined by the beginning or end of ranges relatively long-living foraminifer species. The enclosed table, in which both benthic and selected planktonic foraminifers species are compiled reflects differences in stratigraphic ranges of macro- and microfauna recorded in individual stages, as well as the fact that the ranges of planktonic foraminifers are markedly closer to those of macrofauna than in the case of benthic foraminifers. Zapalowicz-Bilan (1982) compiled table of distribution of benthic species (fig. 5) with reference to definitions of biostratigraphic zones as proposed by Hedberg (1961). In that paper, she used 4 concepts of biostratigraphic zones: range zone, concurrent zone, partial-range zone, and assemblage zone. Unfortunately, no attempt to correlate the zones with those based on macrofauna is given there.

DETAILED PART

In the enclosed table (fig. 6) only species most important for stratigraphy of the Upper Cretaceous in central Poland (62 species) are shown. Moreover, ranges of 85 species were shown in our paper on Cretaceous-Tertiary boundary (K. Pozaryska and E. Witwicka, 1980).

CENOMANIAN

In the Polish Lowlands, the Albian-Cenomanian boundary is characterized by extinction of the following species (Gawor-Biedowa, 1972): *Globigerinelloides bentonensis* (Morrow), *Pleurostomella reussi* Berthelin, *Globorotalites polonica* Gawor-Biedowa, *Gavelinella intermedia* (Berthelin). The boundary is passed by *Gavelinella varsoviensis* (Gawor-Biedowa), which is recorded up to the middle of this stage, and *Gavelinella cenomanica* (Brotzen), approaching but not reaching base of the Turonian. *Orithostella* (recte *Lingulogavelinella) formosa* (Brotzen), appearing for the first time in the Lower (but not the lowermost) Cenomanian, and *Rotalipora cushmani* (Morrow), also do not pass into the Turonian. The Cenomanian-Turonian boundary is passed by *Dorothia gradata* (Berthelin), *Gavelinella belorussica* (Akimez) and *Lingulogavelinella globosa* (Brotzen). Planktonic species *Praeglobotruncana stephani* (Gandolfi), appearing in higher part of the Cenomanian, pass into the Turonian.

TURONIAN

Marginotruncana renzi (Gandolfi) and *Helvetoglobotruncana helvetica* (Bolli) first appear at the Cenomanian-

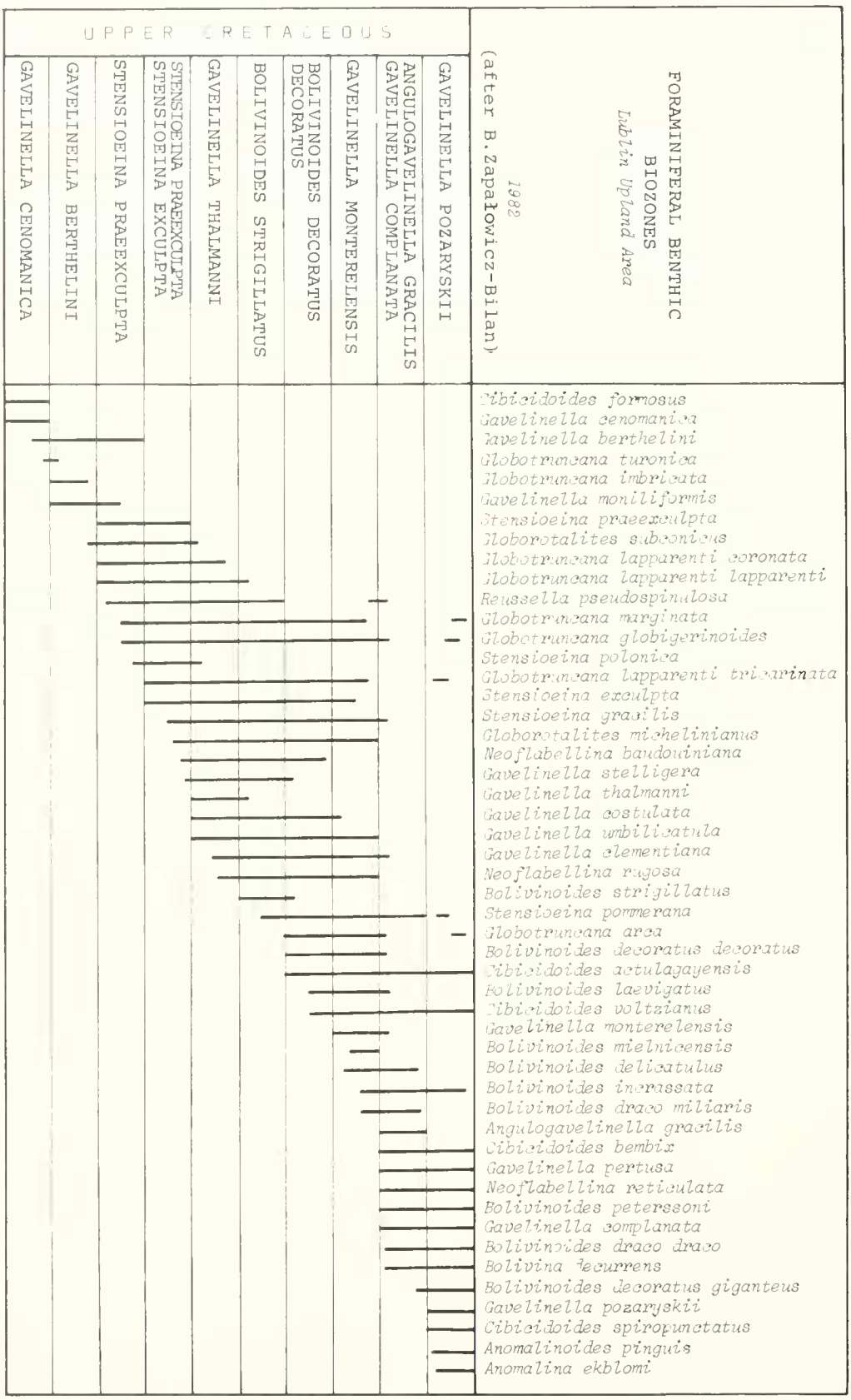

Fig. 5. Biozonation of the Upper Cretaceous in central Poland on the basis of benthic foraminifers

Turonian boundary to occur up to the Lower-Middle Turonian boundary. Other species appearing for the first time at the base of the Turonian include *Globorotalites hangensis* Vassilenko, *Gaudryina angustata compressa* (Akimez) and *Dicarinella imbricata* (Mornod). Guide species for the whole Turonian include *Gaudryina angustata angustata* Akimez and *Gavelinella berthelini* (Keller). First representatives of foraminifers ascribed to *Stensioeina* ex gr. *granulata* (Olbertz) are not known to appear in rocks older than the middle part of the Turonian in the Polish Lowlands. Koch (1977) analysed in detail distribution of that species in the Upper Cretaceous of FRG and he showed its stratigraphic value. Such analysis is still not finished in our country but it may be noted that specimens close to *S. granulata* (Olbertz) occur here from the Turonian to Coniacian, inclusively, They are assigned to *S.* ex. gr. *granulata* (Olbertz) in Tafel 1 as their analysis is still not finished but it may be added that they presumably belong to more than one species. Foraminifers appearing for the first time in higher Turonian in Poland include *Marginotruncana coronata* (Bolli) and *M. pseudolinneiana* Pessagno.

CONIACIAN

No foraminifer species were found to be limited to that stage only. The Turonian-Coniacian boundary is usually delineated with reference to appearance of representatives of *Stensioeina exsculpta* Reuss. In Germany, this species appears somewhat higher (Koch 1977) and it is known to disappear in the Lower Campanian. The range of *Gavelinella stelligera* (Marie) is similar.

Upper parts of the Coniacian and Santonian (except for its top parts) are characterized by representatives of *Gavelinella thalmanni* (Brotzen).

SANTONIAN

The Coniacian-Santonian boundary is defined by the appearance of first representatives of *Stensioeina polonica* Witwicka. It should be noted that Koch (1977) put this name into synonymy of *S. granulata* (Olbertz) but he admitted stratigraphic value of the former. The stratigraphic range of *S. polonica* (Witwicka, 1958) in Germany is very close to that established in Poland.

Stensioeina gracilis Brotzen is another species of that genus which appears at the Coniacian-Santonian boundary. At that boundary, there also appears *Globorotalites multisepta* (Brotzen), characterized by very long range as it is known up to the lowermost Maastrichtian.

The uppermost Santonian is characterized by the appearance of representatives of *Bolivinoides strigillata* (Chapman). The range of that species is very short as it disappears in the lowermost Campanian. In the uppermost Santonian there are also recorded several species which are known to be present up to the top of the Campanian and even to enter the Maastrichtian: *Anomalina clementiana* (d'Orbigny), *Globotruncana fornicata* Plummer, *G. arca* (Cushman) and *Stensioeina pommerana* Brotzen. First of these species disappears in the lowermost Maastrichtian, the last in the Middle Maastrichtian, and the two remaining species are still recorded in the Upper Maastrichtian in the Lublin region, where they form a weakly marked horizon.

CAMPANIAN

The Santonian-Campanian boundary cannot be accurately defined on the basis of foraminifera as up to the present there were not recorded species which would appear or disappear at that boundary. However, the boundary may be delineated with reference to abundant occurrence of representatives of *Cibicidoides involuta* Reuss, first appearing just above the top of the Santonian. The species passes the Campanian-Maastrichtian. Some authors consider this species as guide for the Campanian and Maastrichtian.

In the lowermost Campanian, there appear numerous representatives of the genus *Bolivinoides: B. sidestrandensis* Barr, *B. decorata decorata* (Jones) and *B. laevigata* Marie. They are accompanied by those of the species *Globotruncana ventricosa* White, which are not known from the Maastrichtian.

The uppermost Campanian is characterized by the species *Bolivinoides miliaris* Hiltermann and Koch, *Neoflabellina praereticulata* Hiltermann, *Globotruncana pozaryskae* Peryt. These species continue to occur roughly to the middle of the Maastrichtian, and they are accompanied by *Cibicidoides voltzianus* (d'Orbigny), *C. bembix* (Marsson), *Bolivina incrassata* Reuss and *Rugoglobigerina milamensis* Smith and Pessagno, which occur up to the Cretaceous-Tertiary boundary.

MAASTRICHTIAN

The Lower Maastrichtian is characterized by appearance of the species *Angulogavelinella gracilis* (Marsson). Somewhat above the base of the Maastrichtian appear *Rugoglobigerina pennyi* Brönnimann, and in middle part of that stage – *Globotrunana elevata* Brotzen. Along with the latter, there appears *Bolivinoides peterssoni* Brotzen which is known also from the Tertiary. Along with *Rugoglobigerina pennyi* Brönnimann, there also appear *Pseudouvigerina cristata* Marsson and *Neoflabellina reticulata* (Reuss). The three species pass into the Upper Maastrichtian.

In the Polish Lowlands, the Upper Maastrichtian is characterized by important foraminifer species including *Guembelitria cretacea* Cushman, *Bolivinoides draco* Marsson, *Gavelinella gankinoensis* Neckaja, *Anomalinoides pinguis* (Jennings), *Bolivinoides decorata gigantea* Hiltermann and Koch, *Rugoglobigerina rotundata* Brönnimann and *R. macrocephala* Brönnimann. The latter four species define upper part of the Upper Maastrichtian. *Planoglobulina acervulinoides* (Egger) forms a weakly marked horizon in the Upper Maastrichtian, showing connection of the Late Cretaceous basin from the present area of Poland and warm Tethyan seas. Outside Lublin region, this species is not known in the Polish Lowlands.

In the middle part of the Maastrichtian, the last representatives of the genus *Stensioeina* (*S. pomerana* Brotzen) became

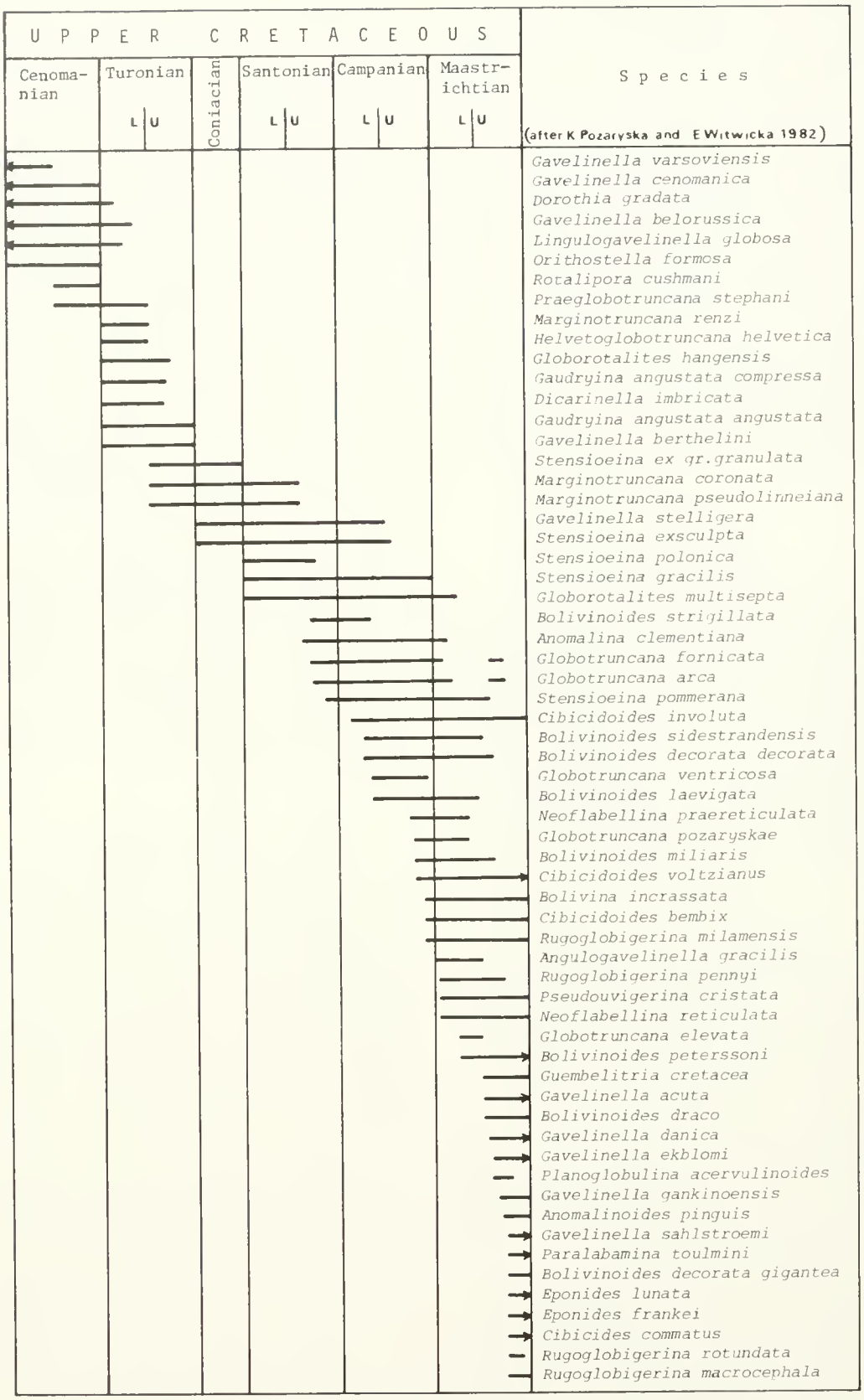

Fig. 6. Stratigraphic ranges of benthic and planktonic foraminifers most important for stratigraphy of the Upper Cretaceous in central Poland

extinct in Poland. Following WICHER (1954), part of the Maastrichtian, situated above the range of *S. pommerana* BROTZEN, is defined in Poland as a horizon without representatives of *Stensioeina*.

In the Polish Lowlands, the uppermost Maastrichtian yields several representatives of species passing the Maastrichtian-Danian boundary: *Bolivinoides peterssoni* BROTZEN, *Gavelinella acuta* (PLUMMER) hitherto known from the Maastrichtian under the name *G. praeacuta* (VASSILENKO), *G. danica* (BROTZEN), *G. ekblomi* (BROTZEN), *G. sahlstroemi* (BROTZEN), *Paralabamina toulmini* (BROTZEN), *Eponides lunata* BROTZEN, *E. frankei* BROTZEN and *Cibicides commatus* MOROZOVA.

The Upper Cretaceous section of the Polish Lowlands appears very similar to those of the GDR and FRG on one hand, and those of European part of the USSR on the other. This was shown in excellent works of TRÖGER (1966, 1967), who established detailed zonation of the Upper Cretaceous on the GDR on the basis of inoceramids. Analysis of that zonal scheme shows numerous species in common with Poland, where they were also found to be of marked stratigraphic value (Fig. 4 here). It may be stated that the whole lower part of Upper Cretaceous in Poland and GDR is characterized by similar succession of inoceramids.

The micropaleontological stratigraphy of the sequences in GDR and FRG was best compiled by HILTERMANN and KOCH (1962, 1977). In these and other papers, the authors made attempts to use various groups of foraminifers and to test stratigraphic value of individual species, taking into account their intraspecific variability. This resulted in proposal of several varieties, especially in the case of species of the genera *Neoflabellina*, *Bolivinoides*, *Stensioeina*. However, subtle morphological criteria not always appeared sufficient for establishing a detailed and at the same time, firm stratigraphic subdivision. That is why we are trying to avoid the usage of subspecies and varieties in stratigraphic studies in our country.

The comparison with foraminifer-based biostratigraphic subdivision established for the Upper Cretaceous in European part of the USSR also showed marked similarities. Species recorded both in Polish Lowlands and the latter region are fairly common and the subdivisions established also appear similar in several points. This is especially the case of lower part of the Upper Cretaceous as shown by GRIGJALIS, AKIMEZ and LIPNIK (1980). It should be noted that biostratigraphic subdivision different of that for the Upper Cretaceous of Ukraine, Lithuania and Byelorussia is needed for the Mangyshlak Peninsula Cretaceous.

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